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THE ACMITIC PYROXENES

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INTRODUCTION

Tschermak, in 1871, showed that the then supposedly distinct species of the pyroxene group, acmite and aegirite, are chemically alike, that is, essentially $\text{Na}_2\text{O} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SiO}_2$. Both names have persisted. Brownish, slightly pleochroic crystals are usually called acmite, while those that are greenish and are decidedly pleochroic are called aegirite. Entirely homogeneous crystals, composed of only the brown or the greenish variety, are rare, and some of the megascopically brown acmite is colorless when seen in thin section. If both varieties occur in the same crystal the arrangement is generally zonal, most often the brown or colorless material forming the exterior: less often the distribution is irregular. The term aegirite-augite, proposed by Rosenbusch¹ to denote pyroxenes intermediate in chemical and optical characters between aegirite and augite occurs frequently in petrographic literature. Other names² have not met with general acceptance.

The present study was begun to test a suggestion³ that the difference between the yellow-brown acmite and the greenish aegirite is connected with the presence of zirconia and oxides of cerium and of other rare earth metals in the former and their absence from the latter. This hypothesis was based on the usual yellowish or brownish color of the zirconia-bearing pyroxenes and of the minerals that contain much cerium and yttrium. The results of our investigation are not confirmatory of this hypothesis, although they show that zirconia and some of the rare earths are commonly present in acmite while they are usually absent from aegirite. Our investigation gradually extended beyond its original

¹ Rosenbusch: *MIKR. PHYSIOL.*, **1**, 537 (1892).

² (Urbanite), Sjögren: *Geol. För. Förh.*, **14**, 251 (1892); (Federovite), Viola: *Neues Jahrb.*, **1**, 121 (1899).

³ Washington: *Quart. Jour. Geol. Soc.*, **70**, 294 (1914).

object, and we have obtained and studied material that covers a considerable range in composition and diversity in locality. The preparation of material and the optical measurements have been done by Merwin and the new analyses and densities by Washington.

METHODS

All the material that was studied by us is considered to have been of a very high degree of purity and as homogeneous as was possible with the strong tendency to zonal structure shown by the pyroxenes.

The general methods used for the chemical analyses were those advocated by Hillebrand and by Washington. In the determination of ferrous oxide the powder was not ground very fine, so as to avoid oxidation. Titanium and manganese were determined colorimetrically. Zirconia and the rare earths were determined by the method (A) of Hillebrand,⁴ with some slight modifications. The mineral powder was dried at 110° before analysis.

The density was determined on the fragments used for the chemical analysis with the pycnometer devised by Johnston and Adams,⁵ and the values reported are regarded as accurate to the second decimal, although the quantity of the material was usually not suitable for very accurate density determinations.

The fragments used for the optical determinations were some of the material that was reduced to powder for the chemical analysis. Portions of the powders analyzed were used in determining the limits of homogeneity and for the final values of the general optical properties.

Extinction angles were determined on cleavage flakes and were measured from cleavage traces; therefore, errors of about $\pm 1^\circ$ may be expected. Refractive indices were measured microscopically by immersion methods, and are given in Table IV. Measurements of dispersion were obtained by means of prisms. For these measurements the strong lines of mercury and helium and a spectrometer-monochromator were used. Because of strong absorption toward the ends of the spectrum the large angle prisms necessary for accurate measurements of dispersion must be sharp-edged, and account must be taken of the rounding of the

⁴ Hillebrand: *U. S. Geol. Survey, Bull.* **700**, 173 (1919).

⁵ Johnston and Adams: *Jour. Amer. Chem. Soc.*, **34**, 566 (1912).

faces very near the edges. Results of the measurement of about a dozen suitable prisms of the purest acmites give dispersions that are practically the same. These are gathered into a single set which, together with those made on the augitic acmite of Laven, appear in Table III.

Color could not be designated satisfactorily for two reasons: (1), large variations were commonly found in single crystals; (2), the collection of the necessary quantitative data concerning light transmission of the crystals could not be undertaken. Yet an attempt has been made to designate the colors transmitted by microscopic grains, so that a fairly definite idea of them may be had. The transmitted colors were compared with the colors of Ridgway's standards⁶ by viewing both simultaneously under diffused light and interchangeably with both eyes, one eye seeing the transmitted color and the other the diffused (standard) color, surrounded by a white background illuminated to match approximately the white field of the microscope. Grains of such thickness were selected as to show the greatest purity and brightness when in the position of greatest absorption. In these standards, hues from red to violet are numbered 1 to 59, but those that represent these pyroxenes fall between orange-yellow (14) and yellow-green (25), yellow being 17. Progressive darkening is shown by the letters *i* to *m*, whitening by *a* to *f*, and dulling or graying by the superscripts ' to ''''.

CALCULATION OF THE MOLECULAR COMPOSITION

All the specimens of acmitic pyroxene that we have examined, and those that have been described by others, are chemically complex, so that any calculation of the molecular composition from the chemical analysis demands the assumption of the presence of several different silicate molecules. The acmitic pyroxenes must be assumed to be composed essentially of metasilicate molecules, as has been assumed by other students of the pyroxene group. The chief molecules in the acmitic pyroxenes are: $\text{Na}_2\text{O} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SiO}_2$ (acmite), $\text{CaO} \cdot \text{MgO} \cdot 2\text{SiO}_2$ (diopside), and $\text{CaO} \cdot \text{FeO} \cdot 2\text{SiO}_2$ (hedenbergite), which may crystallize as monoclinic pyroxenes, and may form series between the end-members. There may also be assumed to be present in some cases the mole-

⁶ Ridgway: Color Standards and Color Nomenclature, Washington, 1912. Appropriate, ordinary color names are used in addition to his names and symbols.

cules: $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ (jadeite), and a vanadous acmite, $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_3 \cdot 4\text{SiO}_2$. In a few cases, in which there is an excess of Na_2O over (R_2O_3) , sodium metasilicate, $\text{Na}_2\text{O} \cdot \text{SiO}_2$, may be assumed to be present. The small amount of K_2O is computed with Na_2O and that of MnO with FeO , the optical effect of the members of each pair being very similar.

If there is an excess of $\text{FeO} + \text{MgO}$ over CaO an arbitrary choice must be made as to which of these is to be given the preference. We give the preference to FeO , first calculating as much hedenbergite as possible, and then allotting the remaining CaO to MgO to form diopside. This procedure was adopted because it was found that, in most acmitic pyroxenes, and especially in those most nearly pure acmite, the hedenbergite molecule is more abundant than that of diopside.

In those cases in which there is an excess of either Fe_2O_3 or Al_2O_3 , or both, over Na_2O , different methods of procedure, or different interpretations of the molecules present, are possible. The assumption of the molecules $\text{FeO} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SiO}_2$ and $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ was made in discussing the composition of babingtonite,⁷ which, however, is not like acmite in crystal structure. Another interpretation is that the excess ferric oxide and alumina may be regarded as forming the simple silicates $\text{Fe}_2\text{O}_3 \cdot 3\text{SiO}_2$ and $\text{Al}_2\text{O}_3 \cdot 3\text{SiO}_2$. We have adopted here, tentatively, the second interpretation, because of our ignorance of the roles played by these oxides when present in excess. In the acmitic pyroxenes excess $(\text{Fe}, \text{Al})_2\text{O}_3$ cannot be regarded as present in solid solution uncombined with SiO_2 , as we have assumed to be the case with augite.⁸ In the specimens of acmitic pyroxenes studied by us this procedure leads to the presence of a large excess of SiO_2 , whereas there is no, or only a slight excess of SiO_2 if (R_2O_3) be assumed to be combined with SiO_2 in the ratio of 1:3.

The small amount of "extraneous substances," as TiO_2 , ZrO_2 , and $(\text{Ce}, \text{Y})_2\text{O}_3$, we have disregarded in our calculations because of the uncertainty as to their functions. That zirconia and the rare earths are present in readily determinable amounts and in larger percentages in the more acmitic members of the group is, for the present, the most interesting feature concerning them.

⁷ Washington and Merwin: *Am. Mineral.*, 8, 221 (1923).

⁸ Washington and Merwin: *Am. Jour. Sci.* 3, 119 (1922).

NOMENCLATURE

Any nomenclature represents a point of view or an attempt at correlation—in mineralogy, particularly, a concept of the chemical composition and the crystallography of the mineral. The monoclinic pyroxenes are so complex from any point of view that, at present, no nomenclature can be generally acceptable. We venture, however, to suggest for them a nomenclature that seems, to us, to be rationally applicable to those species that may be considered to be pyroxenes with diopsidic structure.⁹ In this paper we are dealing especially with pyroxenes that are rich in soda. Such pyroxenes can now, however, be classified only very roughly by optical or other physical means. Those suitably homogeneous specimens that have been analyzed chemically may be classified and named more definitely, but unless such a designation recognizes the physical characters it is not generally applicable.

As has been said, from the chemical standpoint the molecules: acmite ($\text{Na}_2\text{O} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SiO}_2$), diopside ($\text{CaO} \cdot \text{MgO} \cdot 2\text{SiO}_2$), hedenbergite ($\text{CaO} \cdot \text{FeO} \cdot 2\text{SiO}_2$), and jadeite ($\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$), are the chief end-members in the pyroxenes under consideration. Diopside and hedenbergite are, in very different relative amounts, the chief constituents of augite. The term "augite" is limited by most authors to the pyroxenes of such general composition that contain Al_2O_3 (and Fe_2O_3) in indefinitely small amounts. This limitation does not seem to us to be desirable, inasmuch as recent studies indicate that, in these diopside-hedenbergite pyroxenes, the Al_2O_3 and Fe_2O_3 (above what may belong to jadeite or acmite molecules), are present in solid solution and that the so-called Tschermak molecule is non-existent.¹⁰ Furthermore, critical examination of the older (and some of the modern) analyses of augite, as noted by various authors¹¹ and by ourselves, indicates the serious imperfections of many of them, especially in that the amount of Al_2O_3 reported is too high and that of MgO is correspondingly too low, because of a frequently committed and often mentioned analytical error. We, therefore, use the term "augite"

⁹ Wyckoff, Merwin, and Washington: *Am. Jour. Sci.*, **10**, 383 (1925).

¹⁰ Washington and Merwin: *Am. Jour. Sci.*, **3**, 119 (1922). Cf. Boeke: *Grundlagen Phys.-chem. Petrog.*, 190 (1915); and Gossner: *Zeits. Kryst.*, **60**, 76 (1924).

¹¹ Boeke: *Zeits. Kryst.*, **53**, 445 (1914); *Neues Jahrb. Cb.*, **1** (1915); Zambonini: *Atti Accad. Sci. Napoli*, **16**, No. 2, 9 (1914); Tschermak: *Neues Jahrb. Cb.*, 225 (1915); *ditto*, **1** (1916); Gossner: *Zeits. Kryst.*, **60**, 76 (1924).

to denote intermediate members of the diopside-hedenbergite series, disregarding their content in $(\text{Al,Fe})_2\text{O}_3$. It would correspond to the term "olivine" as used to denote intermediate members of the forsterite-fayalite series.

In cases where the characterization is sufficiently definite, the nomenclature that we have adopted for the acmite-diopside-hedenbergite sub-group (the acmitic pyroxenes) is as follows. The divisions suggested are to be regarded as not mathematically sharp but as subject, to some extent, to the judgment of the observer. The pyroxenes are markedly zonal, so that, in most cases, optical methods or chemical analysis determine only approximate averages, and a chemical analysis is not always practicable. Even when this is possible the presence of what we have called "extraneous substances," although in small amount, is a disturbing factor.

(1). If there be present 80 percent or more of one of the end-members the mineral is called by the name of this end-member—acmite, diopside, or hedenbergite. (2). If only two end-members are present we use such names as acmitic diopside and diopsidic acmite, but members intermediate between diopside and hedenbergite, with 10 percent or less of acmite, we call augite. (3). If all three end-members are present in large amount the names acmitic augite and augitic acmite would apply.

When a thorough study of an acmitic pyroxene has been made such cumbrous terms as acmitic diopsidic hedenbergite may be used, but a formula such as $\text{Ac}20 \cdot \text{Di}30 \cdot \text{Hd}40 \cdot \Delta 10$ seems preferable. In this suggested type of formula the figures refer to the weight percentage of the chief molecules and the Δ to the difference between these and 100 percent.

DESCRIPTION OF SPECIMENS

In the description of the specimens examined by us we shall follow the order of the percentage of the acmite molecule, as calculated from the analysis. The various analyses are collected in Table I and the molecular compositions calculated from them are given in Table II. The results of some special measurements to determine dispersion are given in Table III, and the measured refractive indices and extinction angles are collected in Table IV.

ACMITE, ARTIFICIAL. Acmite is easily made synthetically.¹² We prepared it by fusing an intimate mixture of the proper mole-

¹² Cf. Bäckström: *Bull. Soc. Geol. France*, 16, 130 (1893); Weyberg: *Neues Jahrb. Cb.*, 717 (1905).

cular amounts of precipitated silica, ferric oxide, and $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$, with twice as much sodium chloride. The acmite was not analyzed because it was impracticable to obtain sufficient material of a proper degree of purity. Its optical properties agreed with those extrapolated from natural crystals. Attempts at making potassic acmite in a similar way failed.

The crystals of artificial acmite are very thin blades, about 0.05 mm. long and 0.01 wide, elongated parallel to the c axis and flattened parallel to a (100). Singly, the crystals are very faintly yellow, with slight pleochroism; but in mass the dry powder was dull orange-yellow ($17'''c$). The extinction angle, $\alpha \wedge c$, is approximately 8° for red and 10° for blue. The refractive indices determined were: $\alpha = 1.776 \pm .003$, and $\gamma = 1.836 \pm .004$. By inference, from observations on nearly pure natural crystals by Brögger, Wülfing, and ourselves, $-2V = 62^\circ$ for deep red and 60° for blue, and $\beta = 1.819 \pm .004$; α is in the obtuse angle β . Inspection of our data on natural crystals shows that the artificial crystals are not much more refringent than the purest natural acmite. This is in accord with the nearly balanced effect of TiO_2 and excess Fe_2O_3 against silicates of alumina, lime, and magnesia. Ferrous metasilicate must have about the same refringence as acmite. The optical dispersion of pure artificial acmite is estimated to be about 6 percent greater than that of the Rundemyr and Quincy crystals.

ACMITE, QUINCY, MASSACHUSETTS. The crystals of the Quincy acmite that we studied were from the same lot as those described by Palache and Warren,¹³ and were kindly given us by Professor Palache. These authors call the mineral aegirite.

The megascopically very dark green crystals show great variation in color by transmitted light, the color varying irregularly from the greatly predominating green to brown or yellow, often in the same crystal. The pleochroism of the greater part of the crystals is dull yellowish green and dull greenish yellow. The extinction angle, $\alpha \wedge c$, is 7° for blue and $5\frac{1}{2}^\circ$ for red, presumably in the obtuse angle β ; Palache and Warren give 6° for white light. The refractive indices, measured on several prisms, vary about $\pm .002$ from: $\alpha = 1.767$, $\beta = 1.806$, $\gamma = 1.823$. The optic axial angle, $2V_{\text{Na}}$, measured with the microscope, is $60^\circ \pm 3^\circ$, and $\rho > \nu$. Near one optic axis the blue hyperbola is distinctly on the concave side, near the other axis it is barely on the convex side. For the dis-

¹³ Palache and Warren: *Am. Jour. Sci.*, **31**, 550 (1911); Warren and Palache: *Proc. Am. Acad.*, **47**, 157 (1911).

persion and for special measurements of the refractive indices see Table III.

The specific gravity, as determined by Palache and Warren, is 3.499 at 25°; we obtained the value 3.587 at 16°.

Warren states that the carefully selected material analyzed by him contained "only a little ilmenite and traces of octahedrite and quartz." An analysis was made by us of the material that had been used for the optical measurements, which contained none of the impurities mentioned by Warren: it was boiled with dilute hydrochloric acid to remove any parisite, a mineral that contains rare earths. The results of Warren's and our analyses are given here, the mean of the two being given in No. 1 of Table I. In this mean the Al_2O_3 of Warren's analysis is corrected for the zirconia and the rare earths found by us. In recalculating the molecular composition of this mean we have neglected the small amounts of impurities mentioned by Palache and Warren as present in their material.

ANALYSES OF QUINCY ACMITE

	Warren	H.S.W.		Warren	H.S.W.
SiO_2	51.73	52.48	MnO	0.60	0.10
TiO_2	0.64	0.57	MgO	0.14	0.15
ZrO_2	n.d.	0.41	CaO	0.87	0.28
Al_2O_3	1.91	0.96	Na_2O	11.43	12.05
$(\text{Ce}, \text{Y})_2\text{O}_3$	n.d.	0.48	K_2O	0.40	0.35
Fe_2O_3	31.86	31.74	$\text{H}_2\text{O}+$	0.20	n.d.
FeO	0.87	0.93	F	none	n.d.
				100.65	100.50

ACMITE, ROCKALL. Acmite forms about 40 per cent of a peculiar granitic rock (rockallite) that occurs on the islet of Rockall, in the North Atlantic, quartz and albite, in about equal parts, making up the rest.¹⁴

Most of the small prisms of acmite are zonally colored, with a green interior and a brown border. The refractive indices, of the green portion as determined by Dr. F. E. Wright,¹⁴ are: α = about 1.765, γ > 1.80 < 1.82, the refractive indices for the brown portion being "practically the same as the green, but possibly a little higher." The extinction angle, $\alpha \wedge c$, for the green varies from 3° to 5°, that of the brown being slightly higher.

¹⁴ Washington: *Quart. Jour. Geol. Soc. London*, 70, 294 (1914). Cf. Lacroix: *C. R. Acad. Sci.*, 173, 267 (1924).

The specimen of rockallite studied was too small to permit the separation of sufficient acmite for analysis, but its chemical composition was calculated from that of the rock. The result is shown in No. 2 of Table I. The high content in zirconia and the rare earths is noteworthy. The rock itself is high in these oxides, and in the calculation they have been assigned to the acmite because, in our specimen, there is no other mineral present of which they can form part.

Raoult also found zirconia and the rare earths in his analyses of the rocks from Rockall studied by Lacroix, who, in the paper cited above, suggests that the zirconia and the rare earths belong, not to acmite, but to eucolite and elpidite, small quantities of which Lacroix found in his specimens. A reëxamination of the thin sections of our specimen of rockallite failed to show the presence of either of these minerals, so that we believe that the Rockall acmite contains considerable amounts of zirconia and the rare earths. This view is strengthened because we have found quite notable amounts of these oxides in acmite from several other localities.

ACMITE, RUNDEMYR, NORWAY. The single crystal of acmite from Rundemyr that we especially studied came from the Brush Collection in New Haven and was kindly given to us by Professor Ford. Professor Jacob Schetelig, of Oslo, also kindly sent us several excellent crystals from this locality; as these agreed in their optical characters with that from the Brush Collection they were not further examined.

The crystal studied by us was about 3 centimeters long, flattened parallel to $a(100)$, with good cleavage parallel to $m(110)$ and fair cleavage parallel to $b(010)$. It contained no inclusions. Although the crystal looked black, because of the dark greenish interior, an outer zone, one millimeter thick, was light yellow-brown. Prisms were cut for measuring dispersion (see Table III), and the brown exterior was found to be scarcely different from the greenish interior. The pleochroism of both the brown and the green portions was faint, α in olive-greens, and γ in yellow-browns. The refractive indices for the D lines were as follows: for the interior, $\alpha=1.770$, $\beta=1.811$, $\gamma=1.825$; for the exterior, $\alpha=1.771$, $\beta=1.811$, $\gamma=1.825$. The maximum extinction is 2° for red and 4° for blue.

About 3 grams of carefully picked material, made up of both the greenish inner and yellow outer portions, was available for

analysis. Zirconia and the rare earths were determined in a separate portion weighing .9444 gram, and the high percentage of rare earths is noteworthy. The cerium oxide was reddish brown, presumably because of the presence of praseodymium, but the yttrium oxide was pure white. The results of the analysis are given in No. 3 of Table I.

ACMITE, KANGERDLUARSUK, GREENLAND. Our specimen, obtained from Foote and Co., consisted of stubby to elongate, squarish black prisms, with rounded terminations, from 3 to 5 millimeters long, implanted on a somewhat decomposed nephelite syenite. On the acmite crystals are implanted a few small, colorless and water-clear crystals of apatite, which show the prism, base, and unit pyramid. This occurrence does not seem to have been listed by Ussing.¹⁵

Transmitted light showed irregular variations in color, including dull yellows and yellow-greens. The extinction angle, $\alpha \wedge c$, is 3° for red ($650 \mu\mu$) and 5° for blue ($500 \mu\mu$), in the obtuse angle β . The refractive indices and dispersion (Table III) were obtained from oriented prisms, cut from near the free ends of the crystals. These gave the values: $\alpha_D = 1.769$, $\beta_D = 1.805$, $\gamma_D = 1.824$. Near the ends of the crystals (the portion analyzed) variations of 0.005 were observed. The density was found to be 3.509 at 21° .

The chemical analysis was made on 1.2630 grams of very carefully selected material, the results being given in No. 4 of Table I. Zirconia and the rare earths were determined in the mixed residues from the portions used for ferric oxide and titanium, ferrous oxide, and the alkalies, altogether amounting to 0.7162 gram. Three analyses of the Kangerdluarsuk acmite by Doelter¹⁶ and by Lorenzen¹⁷ resemble ours in general features, our figures for most of the constituents being about the mean of the three.

ACMITE, "BREVIK," NORWAY. The material studied by us was a rough crystal from the Brush Collection sent us by Professor Ford. The locality of the specimen is not definite, as "Brevik" is a dealer's name for the district.

The black crystal yields a light tea green ($25''''b$) powder, the grains showing faint pleochroism in dull yellowish green and olive buff. The extinction angle on cleavage flakes, $\alpha \wedge c$, is 0° for red

¹⁵ Ussing: *Medd. Groenl.*, 32, 211 (1905).

¹⁶ Doelter: *Zeit. Kryst.*, 4, 35, 37 (1879).

¹⁷ Lorenzen: *Min. Mag.*, 5, 55 (1882).

and 1° for blue. The refractive indices vary about $\pm .005$ from the following: $\alpha=1.76$, $\beta=1.79$, $\gamma=1.81$. The specific gravity is 3.591 at 21° .

Chemical analysis yielded the results given in No. 5 of Table I. The composition is much like that of other acmites of the district, and shows notable amounts of zirconia and the rare earths.

HEDENBERGITIC ACMITE, MAGNET COVE, ARKANSAS. The aegirite of Magnet Cove has been described by J. F. Williams.¹⁸ We have studied material obtained from the U. S. National Museum, and also a portion of the powder used by Steiger for his analysis.¹⁹

The mineral forms long, many of them very large, prisms in a nephelite syenite pegmatite. The mass color of the crystals varies somewhat, but is generally a greenish black. Williams speaks of "a slight tendency toward brownish green in some of the specimens which are superficially weathered," but this is attributed by us rather to the presence of an exterior zone of brown acmite, as aegirite, in general, shows slight tendency to alteration. In powder most of the grains appeared yellowish green, some brown, and some nearly colorless. The pleochroism of the greenest portions is: α =dull yellowish green, and γ =dull yellowish. The pleochroism of the brown portions is: α =olive buff, and γ is lighter, nearly "grape green." Inhomogeneity of the material was indicated by variations of about $\pm .005$ in the values for β —the light colored grains had the higher indices. Average values are about as follows: $\alpha=1.763$, $\beta=1.780$, $\gamma=1.812$, for sodium light. The extinction angle is variable, and grains that showed differences of about 1° between blue and red may have either red or blue showing the maximum angle of about 3° . We obtained the value 3.545 at 22° for the specific gravity of our specimen, while J. Lawrence Smith found that of his to be 3.53.

Three chemical analyses of the Magnet Cove aegirite have been made. That by Steiger is given in No. 7 of Table I; in this are inserted determinations of TiO_2 , ZrO_2 , and $(\text{Ce}, \text{Y})_2\text{O}_3$, made by Washington on some of the original powder, Steiger's figures for Al_2O_3 being corrected for these. An analysis by Washington of another specimen, obtained from the U. S. National Museum,

¹⁸ J. F. Williams: *Ann. Rep. Geol. Surv. Arkansas*, 2, 248 (1891).

¹⁹ Clarke and Steiger: *Am. Jour. Sci.*, 13, 36 (1902); *U. S. Geol. Survey, Bull.* 207, 47 (1902).

is shown in No. 8 of Table I. Smith's²⁰ analysis is as follows: $\text{SiO}_2 = 51.41$, $\text{TiO}_2 = 0.13$, $\text{Al}_2\text{O}_3 = 1.82$, $\text{Fe}_2\text{O}_3 = 23.30$, $\text{FeO} = 9.45$, $\text{MgO} = 0.31$, $\text{CaO} = 2.03$, $\text{Na}_2\text{O} = 11.88$, $\text{K}_2\text{O} = \text{trace}$; Sum = 100.33.

The two analyses by Steiger and by Washington are much alike, and the differences between them may well be ascribed to different proportions of brown and green material in the samples analyzed. Smith's analysis differs more widely from these, especially in FeO, MgO, CaO, and Na_2O . From the variations in the physical properties and in the chemical composition it is apparent that, apart from the somewhat zonal and otherwise non-homogeneous structure of individual crystals, the aegirite of Magnet Cove is somewhat variable in composition, as was pointed out by Clarke and Steiger.

HEDENBERGITIC ACMITE, ARÖ SKJÄR, NORWAY. The specimen came from one of the small rocky islets between Gross Arö and Langoddelen, near the mouth of the Langesund Fjord,²¹ and was kindly given to us by the collector, Dr. Olaf Andersen.

The material consisted of small black crystals in nephelite syenite, but it is not very satisfactory for optical study, as the crystals are irregularly zoned and blotchy. The color of the powder is a dull yellowish green (tea green, 25'''b). The extinction angle varies, being mostly from 1° to 6° for red and slightly less for blue. For the nearly colorless portions $\alpha = 1.765$ and for the strongly greenish portions $\alpha = 1.746$. The results of our analysis are shown in No. 9 of Table I. In chemical composition this aegirite more closely resembles Penfield's specimen from Laven than Washington's.

VANADIFEROUS DIOPSIDIC ACMITE, LIBBY, MONTANA. This mineral has been described by Larsen and Hunt,²² who very kindly furnished us with material from the same locality.

The mass color is nearly black, but thin splinters are brown by transmitted light. According to Larsen and Hunt the pleochroism is: α = dark brown, β = lighter brown, γ = pale yellowish brown or amber. In our specimen α varies between snuff brown and dark Isabella color (14''j and 19''i), and γ between olive buff and citron green (20''h and 25''a). Larsen gives an average extinction angle of 1.4° for sodium light and 1.2° for white light. In our specimen $\alpha \wedge c$, varied from 1° for red and 2° for blue to 1° for

²⁰ J. Lawrence Smith: *Am. Jour. Sci.*, **10**, 60 (1875).

²¹ For map see Brögger: *Zeit. Kryst.*, **16**, Tafel 29 (1890).

²² Larsen and Hunt: *Am. Jour. Sci.*, **36**, 290 (1913).

blue to 2° for red. Larsen's average values for the refractive indices are: $\alpha=1.745$, $\beta=1.770$, $\gamma=1.782$. The specific gravity is 3.55, as determined with a pycnometer by Larsen and Hunt.

The analysis by Hunt gave the results shown in No. 10 of Table I. Zirconia and the rare earths can be present, if at all, only in very small amount, because of the small percentage of Al_2O_3 , with which they would be precipitated and weighed.

HEDENBERGITIC ACMITE, LAVEN, NORWAY. Two specimens from this islet in the Langesund Fjord, where the mineral occurs in coarse nephelite syenite pegmatite,²³ were studied by us. One was collected by Professor Penfield in 1894 and the other by Washington in 1897, both under the guidance of Professor Brögger. Penfield's specimen, which was kindly sent to us from the Brush Collection by Professor Ford, proved to contain too many inclusions to be satisfactory, so that we made a special study of only Washington's specimen.

The material consisted of several loose black crystals, up to 5 centimeters long, most of them flattened parallel to $b(010)$. The material is not much zoned and is free from inclusions. The specific gravity is 3.549 at 22° .

The color in transmitted light is comparatively uniform in very dull greenish yellows. Pleochroism is not very marked. The extinction angle, $\alpha \wedge c$, is 10° for red and $9\frac{1}{2}$ for blue, presumably in the acute angle β . The refractive indices varied ± 0.003 from the following values: $\alpha_D=1.744$, $\beta_D=1.768$, $\gamma_D=1.782$. The optic axial angle— $2V_{Na}=70^\circ$ to 80° . One axis shows no distinct dispersion, the other gave a measured value in air of $4\frac{1}{2}^\circ$ between the hyperbolas for red ($650\text{ }\mu\mu$) and blue ($500\text{ }\mu\mu$), with $b \rightarrow r$. That is to say, the axis for red is beyond the axis for blue with respect to the acute bisectrix. Data as to dispersion of refractive indices will be found in Table III.

Penfield's specimen contains many minute inclusions and perhaps 3 per cent of biotite. The color varies much, the extinction angle varies from 2° for red and 3° for blue to 4° for red and 3° for blue. The refractive indices are so variable that it is not worth while to give our determinations.

Both of the specimens were analyzed, the material of Washington's specimen being from the same crystal that served for the optical determinations. The results are very discordant, as is

²³ Brögger: *Zeit. Kryst.*, 16, 121, 318, 329 (1890).

shown in Table I, Nos. 6 and 11. Washington's specimen is a hedenbergitic acmite, while Penfield's cannot be more definitely named than augitic acmite. From the data given here, and from the work of others, it is apparent that the aegirite of Laven is very variable in composition.

VANADIFEROUS ACMITIC DIOPSIDE, LIBBY, MONTANA. An "aegirite-augite" occurs with the diopsidic acmite near Libby, Montana, which also is notable for its content in vanadium. Dr. Larsen kindly supplied us with some of the material studied by him and Hunt.²⁴

The mineral is pleochroic in dull yellowish and yellowish green, α being yellowish and greenish, while γ is greenish. This peculiar behavior of α , ranging from greener to yellower than γ , is probably due to the influence of the vanadium. The extinction angle, $\alpha \wedge c$, in our specimen is 24° . The refractive indices are $\alpha = 1.720$, $\gamma = 1.747$, according to Larsen, and according to Larsen and Hunt the specific gravity is 3.42. Hunt's analysis is given in No. 12 of Table I. It would appear, from the calculated molecular composition, that the mineral is a vanadiferous acmitic diopside.

ACMITIC-DIOPSIDIC HEDENBERGITE, SALEM NECK, MASSACHUSETTS. This mineral has been described, as aegirite-augite, from thin sections of the nephelite syenite of Salem Neck,²⁵ in which it forms small prisms. From a large specimen of the nephelite syenite of Salem Neck, specially collected for us by Professor J. E. Wolff, a good sample of the pyroxene was obtained. Even these minute crystals were decidedly zoned. The refractive index β varied about ± 0.005 from 1.729. The observed maximum $\gamma = 1.759$, and the minimum $\alpha = 1.711$; $+2V = 75^\circ - 80^\circ$; $\alpha \wedge c = 27^\circ - 32^\circ$. The mineral was markedly pleochroic, γ being brownish and α and β being darker and greenish. The amount of material available was too small for a satisfactory determination of the specific gravity. An analysis, made on 0.9985 gram of selected material, is given in No. 13 of Table I; the amount available was too small to permit the determination of MnO , ZrO_2 , etc.

MISCELLANEOUS. Brief notes are given here on some acmitic pyroxenes, that have been described by others, with optical data accompanying the chemical analyses, some of which we have been able to study optically.

²⁴ Larsen and Hunt: *Am. Jour. Sci.*, **36**, 295 (1913).

²⁵ Washington: *Jour. Geol.*, **6**, 803 (1898).

LUJAVR-URT, KOLA. Hedenbergitic acmite occurs in the lujavrite (nephelite syenite) of this locality, a specimen of which rock was kindly sent us by the late Professor Pirsson, who obtained it from Ramsay. The rock has been described by Ramsay, with an analysis of the aegirite by Forsberg.²⁶

We found the pleochroism of the acmite to be: α =dull green, β and γ dull yellow. The extinction angle $\alpha \wedge c$ is 4° – 5° (Ramsay). We have noted that the angle is about 1° greater for red than for blue, so that α is probably in the acute angle β . The refractive indices for sodium light we found to be: $\alpha=1.760$, $\beta=1.782$, $\gamma=1.816$, with variations of about ± 0.003 . According to Ramsay the average specific gravity is 3.51. The analysis by Forsberg is not very satisfactory.

MONTREAL. Harrington²⁷ described the "aegirite" of the nephelite syenite at the Corporation Quarry, Montreal, and we studied part of Harrington's original specimen, which was kindly sent us by Professor F. D. Adams.

The hedenbergitic acmite forms black crystals in a coarse nephelite syenite pegmatite. The crystals are too much zoned for satisfactory optical study and we made no measurements of the refractive indices. The pleochroism is very strong in parts of the crystal: α =dull yellowish green, γ =dull yellow. The extinction angle of the most deeply colored portions is 6° for red and 5° for blue: that of the practically colorless portions is 6° for red and 6° for blue. Harrington's analysis is incomplete and his figure for MnO appears to be high.

FRENCH RIVER, ONTARIO. An acmite from this new nephelite syenite locality has recently been described by Walker and Parsons,²⁸ with an analysis by Rickaby and optical determinations by Larsen. The chemical composition is that of an acmite but, as remarked by Larsen, the refractive indices are lower than is to be expected from the composition: they approximate to those measured by us on the aegirite of Lujavr-Urt.

LIBBY, MONTANA. Goranson has described, in a recent number of this journal,²⁹ a non-vanadiferous acmitic pyroxene, with an analysis by Miss Vassar. Chemically it resembles our heden-

²⁶ Ramsay: *Fennia*, 3, 40 (1890).

²⁷ Harrington: *Trans. R. Soc. Canada*, 2, (3), 25 (1905).

²⁸ Walker and Parsons: *Univ. Toronto Studies*, No. 22, 12 (1926).

²⁹ Goranson: *Am. Mineral.*, 12, 37 (1927).

bergitic acmite from Magnet Cove (No. 8 of Table I), although it is diopsidic rather than hedenbergitic, as are the two vanadiferous pyroxenes from Libby described by Larsen and Hunt.

GENERAL CHEMICAL CHARACTERS

The acmitic pyroxenes studied by us cover a wide range with respect to both composition and locality. The Tables point to the conclusion that acmite, diopside, and hedenbergite may mix in all proportions in crystals. The hedenbergitic, rather than diopsidic, tendency of the purer acmites is explained by the natural conditions in which they have been formed: the presence of notable amounts of ferrous iron is to be expected, while magnesia is much less abundant than iron in the sodic rocks in which the acmitic pyroxenes occur.³⁰

A striking and seemingly constant feature of acmite proper is the notable content of zirconia and the rare earths, the acmitic pyroxenes that contain much diopside or hedenbergite carrying but traces or none of these. This richness in zirconia and the rare earths is in harmony with the tendency of these oxides to be associated with soda in minerals and rocks.³⁰

³⁰ Washington: *Trans. Am. Inst. Min. Eng.*, **39**, 735 (1909); *Proc. Nat. Acad. Sci.*, **1**, 574 (1915); Clarke and Washington: *U. S. Geol. Survey, Prof. Paper* **127**, 104 (1924).

TABLE I. ANALYSES OF ACMITIC PYROXENES.

	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO ₂	52.10	49.83	51.59	50.83	51.99	51.98	50.45	51.86	51.52	51.91	50.89	53.32	48.38
TiO ₂	0.60	0.78	1.00	0.23	0.56	0.57	0.90	2.06	0.73	0.91	0.54	0.38	1.45
ZrO ₂	0.41	2.68	0.20	0.15	1.34	n. d.	0.08	n. d.	n. d.	n. d.	0.02	n. d.	n. d.
Al ₂ O ₃	0.99	none	2.06	1.76	1.32	0.99	1.78	1.12	1.07	0.38	2.81	1.40	4.51
(Ce, Y) ₂ O ₃	0.48	0.84	1.02 ¹	0.11	0.27	n. d.	none	n. d.	n. d.	n. d.	0.02	n. d.	n. d.
V ₂ O ₅	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	3.98	n. d.	2.86	n. d.
Fe ₂ O ₃	31.80	30.27	28.65	28.70	28.16	27.15	23.42	22.72	26.43	21.79	19.20	12.38	3.43
FeO	0.90	1.78	2.08	3.07	2.18	2.72	5.26	4.30	5.09	1.48	6.87	3.70	17.35
MnO	0.35	0.28	0.14	0.29	0.10	0.08	0.10	0.26	0.43	0.58	0.05	0.45	n. d.
MgO	0.14	0.27	0.35	0.34	0.44	2.19	1.48	2.27	0.60	3.08	2.28	7.01	3.18
CaO	0.57	1.65	0.30	1.30	1.59	4.40	5.92	5.95	4.59	5.53	8.55	12.18	18.07
Na ₂ O	11.74	11.62	12.66	12.63	11.68	9.69	9.84	9.36	8.72	10.46	8.01	6.26	3.30
K ₂ O	0.37	none	0.19	0.36	0.22	0.26	0.24	0.08	0.14	0.22	0.15	9.26	0.44
H ₂ O+	0.20	none	0.09	0.10	0.15	0.25	0.40	0.31	0.43	none	0.41	0.13	0.35
Sp. gr.	100.65	100.00	100.33 ²	99.87	100.00	100.28	100.02 ³	100.29	99.75	100.51 ⁴	99.95 ⁵	100.40 ⁶	100.46
	3.587			3.509	3.591			3.545		3.55	3.509	3.42	
	16°			21°	21°			22°			22°		

¹ Ce₂O₃ = 0.61, Y₂O₃ = 0.41. ² Cr₂O₃ none. ³ H₂O = 0.15. ⁴ H₂O = 0.06, S 0.13. ⁵ Cr₂O₃ none, BaO 0.02, SrO 0.13. ⁶ H₂O = 0.07.

1. Acmite, Quincy, Massachusetts. Mean of analyses by Warren and Washington; see page 240.
2. Acmite, Rockall Island. New calculation from rock analysis. Washington: *Quart. Jour. Geol. Soc.*, **70**, 300 (1914).
3. Acmite, Rundemyr, Norway. Washington analyst.
4. Acmite, Kangerluarsuk, Greenland. Washington analyst.
5. Acmite, "Brevik," of Norway. Washington analyst.
6. Augitic acmite, Laven, Langesund Fjord, Norway. (Penfield specimen.) Washington analyst.
7. Hedenbergitic acmite, Magnet Cove, Arkansas. Steiger analyst, *Am. Jour. Sci.*, **13**, 36 (1902). TiO₂, ZrO₂, and (Ce, Y)₂O₃ by Washington, Al₂O₃ corrected for these.
8. Hedenbergitic acmite, Magnet Cove, Arkansas. Washington analyst.
9. Hedenbergitic acmite, Arö, Skjär, Norway. Washington analyst.
10. Vanadiferous diopsidic acmite, Libby, Montana. Hunt analyst. Larsen and Hunt: *Am. Jour. Sci.*, **36**, 294 (1913).
11. Hedenbergitic acmite, Laven, Norway. (H. S. W.'s specimen.) Washington analyst.
12. Vanadiferous acmitic diopside, Libby, Montana. Hunt analyst. *Op. cit.*, 295.
13. Acmitic diopsidic hedenbergite, Salem Neck, Massachusetts. Washington analyst.

GENERAL OPTICAL CHARACTERS

DISPERSION. Measurements on the most transparent parts of crystals from Rundemyr, Kangerdluarsuk, and Quincy gave dispersions that were identical within 0.0005. For the Quincy crystal the more accurate values (within ± 0.0001) of α and β were obtained between 668 He and F. The Laven crystal is No. 11 of Tables I and II.

TABLE III. DISPERSIONS.

	Quincy			Laven		
	α	β	γ	α	β	γ
G'	1.801 ₇	1.854 ₄	1.877	1.778	1.804	1.822
436 Hg	1.800 ₀	1.852 ₄				
F	1.7853	1.8304	1.850+	1.762	1.787	1.802+
501 He	1.7818	1.8254				
546 Hg	1.7736	1.8142+				
588 He	1.7677+	1.8065				
D	1.7675	1.8062	1.823	1.743+	1.768	1.781+
C	1.7608	1.7474	1.813	1.736+	1.760	1.774
668 He	1.7597	1.7961				

REFRACTIVE INDICES AND EXTINCTION ANGLES. The presence of admixed hedenbergite, diopside, or jadeite modifies the optical properties of acmite. With decreasing content of acmite in the acmitic pyroxenes the refractive indices and their dispersions, and the birefringences (especially $\beta - \alpha$), decrease markedly. $2V$ first increases from -60° to 90° and then decreases to about $+70^\circ$ or $+60^\circ$. The extinction angle, $\alpha \wedge c$, decreases from 9° in the obtuse angle β to 0° , and then increases in the acute angle β to large values. The bisectrices, α_r and α_b , keep the same relative positions with respect to each other, but they are farthest apart in pure acmite. The optic axial angle dispersion, also, is greatest in pure acmite.

TABLE IV. REFRACTIVE INDICES AND EXTINCTION ANGLES.

No.	Locality	α	β	γ	$2V_{\text{Na}}$	$\alpha \wedge c$
	Artificial	1.77 ₆ *	1.81 ₆	1.83 ₆	-60°	8°**
1	Quincy	1.767	1.806	1.823	-60°	6°
2	Rockall	1.765	—	1.81 ₆	—	3°-5°
3	Rundemyr	1.77 ₀	1.81 ₁	1.82 ₅	—	3°—
4	Kangerdluarsuk	1.76 ₉	1.80 ₅	1.82 ₄	—	4°—
5	Brevik	1.76	1.79	1.81	—	0°
7-8	Magnet Cove	1.76 ₃	1.78 ₀	1.81 ₂	—	3° 3°
	Lujaur Urt	1.76 ₀	1.78 ₂	1.81 ₆	—	4°
9	Arö Skjär	{ 1.74+	—	—	—	0°-5°
		1.76+				
10	Libby (acmite)	1.74 ₅	1.77 ₀	1.78 ₂	—	1° 2°
	Libby (Goranson)	1.74 ₂	1.76 ₈	1.78 ₇	-80°±	2°±
11	Laven (H.S.W.)	1.74 ₄	1.76 ₈	1.78 ₂	-70°-80°	10°
12	Libby (diopside)	1.72 ₀	—	1.74 ₇	—	24°
13	Salem Neck	1.72	1.73	1.75	+75°-80°	27°-32°

* Subscripts in refractive indices indicate variations or errors of 0.003-0.005.

** 8°| etc. indicate that α is in obtuse angle β ; |4° etc. indicate that α is in acute angle β .

THE SELENITE CAVES OF NAICA, MEXICO

WILLIAM F. FOSHAG, *U. S. National Museum.*¹

A characteristic feature of many of the ore deposits of Mexico that are found in the Cretaceous limestones of the country is the presence of caves in close association with the ore. One such cave discovered in 1912 during mining operations in the Potosi Mine at Santa Eulalia, but now destroyed, was remarkable for the wonderful beauty of its calcite and gypsum crystal growths. It was the habit to illuminate this cavern with a multitude of candles and for sheer brilliance and delicacy it probably surpassed anything yet discovered. In many of these caves calcite predominates, sometimes as botryoidal masses, sometimes in coral-like groups of crystals or again as entire coatings of dogtooth spar. In a few, gypsum is the chief mineral and it is usually present in most of them.

Of the gypsum caves the most remarkable are those of Naica, a small mining camp in the state of Chihuahua. To reach them one goes to the station of Concho on the Mexican Central R. R. 130 kilometers south of the city of Chihuahua and from here by a narrow gauge line to Naica, a distance of about 30 kilometers.

¹ Published with the permission of the Secretary of the Smithsonian Institution.

There are two caves at Naica, the better known one being that in the Maravilla Mine. The cave is on the third level and is guarded by a heavy wooden door to prevent the entrance of vandals. It is the habit of the owners, the Naica Mines of Mexico, a subsidiary of the Penoles Company, to care for this cave and to prevent as far as possible the marring of its beauty by the promiscuous removal of crystals, a policy that should be respected by all visitors. A short passage leading from the door takes one to a chamber lined on walls and ceilings with numerous colorless crystals of gypsum from six inches to over a foot in length. The floor of the cave is littered with blocks of limestone that have sluffed off the roof and are now covered with a coating of botryoidal calcite and scattered over with long, blade-like or short stumpy crystals of gypsum. In the grottoes between these boulders of limestone are usually one or more clear selenite crystals like figures in niches. The crystals from the roof and upper walls are partially redissolved so that they resemble icicles rather than crystals but those found in the lower portions of the cave are clear, colorless and well formed. Many contain channels filled with water and carry movable bubbles.



Figure 1. Huge Gypsum Crystals, Maravilla Mine, Naica, Chihuahua, Mexico. (Photo by Foshag.)

From this chamber a stairway leads down into an extension where the gypsum crystals have grown to an enormous size. Many of them are four and five feet long and a few probably reach six feet. (fig. 1.) They grow from the floor of the cave in a manner resembling the maguey plants so common on many of the hills of Mexico. These large crystals are colored a light gray by included mud but are often capped by a clear white termination. They are somewhat rounded on their prism zones but are bright and shiny. The walls are studded with scattered crystals of selenite of a stumpy habit. Further on, the way leads thru a narrow opening, just large enough to permit the passage of a man, completely lined with blade-like crystals and forming a veritable corridor of swords. These crystals reach a length of two to three feet and are opaque white in color. From this passage one descends a few feet into the largest chamber of the cave. The floor ahead rises at an angle of about 30° and is completely banked with myriads of selenite blades one to three feet in length. At the crest of the floor there arises a remarkably fine radiated group of crystals over four feet high, gray in color but tipped with white and glistening brightly in the light of the lamps. Nearby is the only huge crystal of the stumpy type noted, a crystal that must weigh sixty pounds. From this single crystal grows a long blade of selenite almost four feet long. Beyond these the cave rapidly narrows until it becomes a mere crack.

A second cave in the neighboring Lepanto Mine adjoins the one in the Maravilla and may actually be a continuation of it. In the one chamber of the cave the front and the right walls are covered with gypsum crystals for about two thirds of their height. The crystals from this cave are entirely of the long bladed habit but are better formed than those of the Maravilla. They lack however, the clear watery transparency of many of those of the latter mine, being colored dark grayish brown by included mud.

As has already been noted the selenite crystals belong to two types: long prismatic blades and short, stubby ones. The prismatic crystals have the faces $b(010)$, $m(110)$ and $n(\bar{1}11)$ and rarely $l(111)$ and are almost invariably twinned after the fashion of fig. 2A and B. By far the commonest habit is for the twins to be terminated by the rear pyramid $n(\bar{1}11)$, simulating orthorhombic crystals like fig. 2A. Very rarely is the crystal terminated by the front pyramid $l(111)$ and then terminated by a re-entrant. Very few were of this latter habit and these were found only after

a special search was made for them. The stumpy habit is relatively much shorter along the c axis so that they may be equi-dimensional or what is still more common, are somewhat elongated along the a axis. They have the prismatic zone deeply striated, $l(111)$ prominent and $n(\bar{1}11)$ very small or absent. These crystals are considerably less abundant than the long bladed form and have only been noted on the walls and in the very lowest portions of the Maravilla cave.

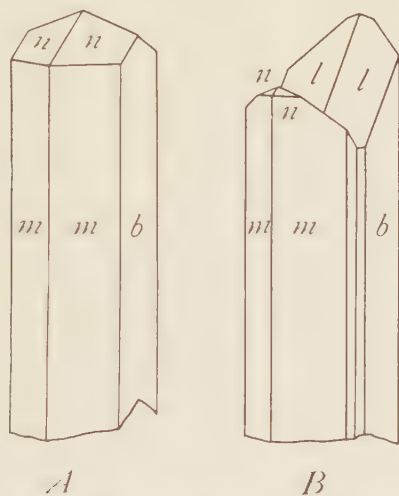


Figure 2. Twin Crystals of Gypsum, Naica, Chihuahua, Mexico.

Many of the caves of the type just described are directly connected with ore bodies. At Los Lamentos, for instance, the caves are considered an almost positive indication of ore below and owe their origin to the oxidation of sulphide ores. Although there is a decided increase in the volume of the minerals upon the oxidation of the sulphides, the sulphuric acid and soluble sulphates generated are removed and accounts for a certain amount of the material lost. These spaces are then often considerably enlarged by the action of surface water to form the larger chambers of the caves. The caves at Naica, however, are as far as is now known, not immediately connected with ore bodies and it is obvious upon an inspection of them that they are greatly enlarged cracks or slightly faulted zones. The enlargement has taken place partly by the action of surface waters but also by sulphate waters, the

result of sulphide oxidation. The manner of growth of the numerous crystals is not clear, particularly as the caves are now completely dry; and no reasonable suggestion as to the growth of the huge crystals from the floor has occurred to the writer.

The author gratefully acknowledges his indebtedness to Prof. Palache for financial assistance from the Holden Fund of Harvard University and to Mr. A. C. Fox, superintendent of the Naica Mines of Mexico, for permission to visit the caves and collect specimens.

EUHEDRAL ORTHOCLASE CRYSTALS FROM SIERRA BLANCA, TEXAS¹

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The crystals described in this paper were found one mile northwest of Sierra Blanca, Hudspeth County, Texas, where a dike of porphyritic igneous rock intrudes Cretaceous limestone. In this dike feldspar crystals occur as phenocrysts in a fine grained but holocrystalline groundmass. The region is arid and in the weathering of rocks disintegration is usually more in evidence than decomposition. In the rock mentioned above disintegration has loosened the feldspar crystals from the groundmass so that great numbers can be picked out, the crystals occurring much as fossils in a well weathered outcrop of sedimentary rock. The great abundance of the crystals, their perfection and relative freshness is thought to warrant a record of the locality.

The crystals secured range in size from 5 mm. to 2 cm. in greatest dimensions, averaging about 1 cm. The freshest specimens are pinkish flesh colored while altered material is chalky. Examination under the microscope shows a slight alteration to kaolinite in many of the specimens but great numbers are practically unaltered. Some of the crystals are imperfect through accidents of weathering although many are perfect. For this study imperfect crystals were discarded, only euhedral ones being included. From a relatively small amount of material 556 essentially perfect crystals were secured and examined.

¹ Published by the permission of the Bureau of Economic Geology, University of Texas.

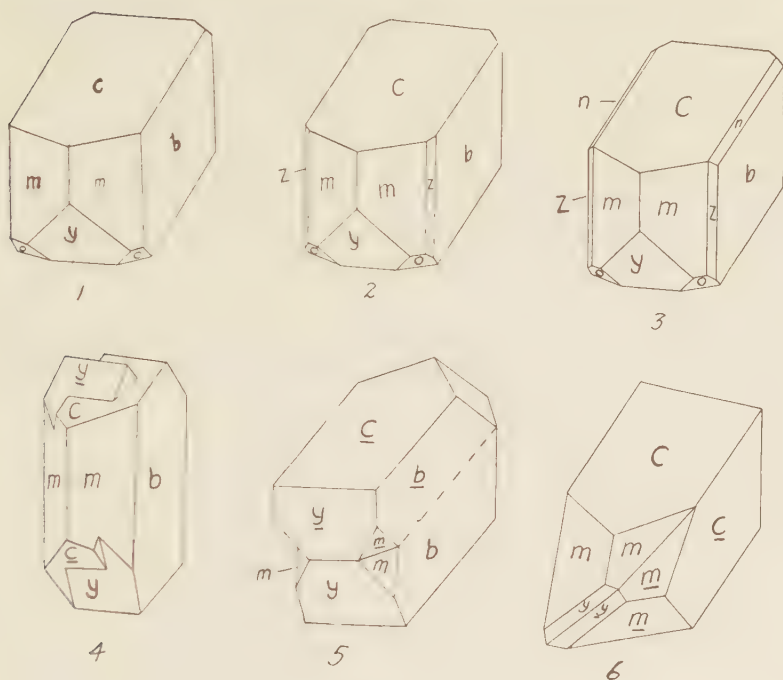


Figure 1.

Figure 1 shows the types of crystals present in the collection. The forms present include $m(110)$, $y(\bar{2}01)$, $c(001)$, $n(021)$, $o(\bar{1}11)$, $b(010)$ and $z(130)$ all determined by inspection only. The combinations and habits are as shown in figure 1. Elongation parallel to a axis is common but not universal since many of the crystals were equidimensional and some were elongated parallel to c . The distribution of types of crystals among the 556 specimens is given below.

Type	Number of Crystals	Per Cent
1	413	74.28
2	51	9.17
3	1	0.179
4	36	6.47
5	51	9.17
6	4	0.719

The simple combination (No. 1) is the most abundant by far, while Baveno twins (No. 6) and the crystal in which both $n(021)$ and $z(130)$ appear (No. 3) are rare. Carlsbad (No. 4) and Mannebach (No. 5) twins are present in nearly the same abundance but are less common than the simple type. Crystals with $z(130)$ are relatively common. The variation in abundance of the different types of crystals furnishes interesting data on the crystallization of orthoclase. It is hoped to make this feature of the study exhaustive by the addition of several thousand crystals to the collection.

A chemical analysis of the feldspar, made in the Industrial Chemistry Experiment Station, University of Texas, is given below.

SiO ₂	61.30
Al ₂ O ₃	17.15
Fe ₂ O ₃	3.47
CaO	2.05
K ₂ O	11.58
Na ₂ O	4.20
H ₂ O—	0.20
H ₂ O+	1.28
	101.23

The analysis does not conform to the theoretical composition of orthoclase. It is believed that most of the irregularities in the result are due to impurities in the mineral which are apparent when the crystals are examined under the microscope, magnetite and an amphibole being present as inclusions in small amounts. The water is of course due to kaolinization. If iron, lime and water are disregarded and the remainder recast to 100 per cent the results correspond approximately to a soda-orthoclase as shown below.

PER CENT		MOLECULAR RATIOS	
SiO ₂	65.05	1.084	= 6 × .174
Al ₂ O ₃	18.20	.178	= 1 × .178
K ₂ O.....	12.29	.130	} = 1 × .201
Na ₂ O.....	4.46	.071	
100.00			

This result approximates the composition of a soda-orthoclase but is slightly deficient in both alumina and silica or has an excess

of the alkalis. The analysis is supported by the optical characters which are shown in the following table.

$\alpha=1.5180$	$X \wedge a=6^{\circ}37'$
$\beta=1.5234$	$Z=b$
$\gamma=1.5260$	$2V=70^{\circ}$ approximate

The orientation and extinction angle corresponds to a soda rich orthoclase. The indices of refraction were obtained by matching liquids with the mineral and the determination of the indices of the liquids by means of the refractometer.

OLIVINE FROM MONHEGAN ISLAND, MAINE

E. P. WHEELER, II, *Cornell University.*

In the spring of 1923 the writer had opportunity to collect a suite of igneous rocks from Monhegan Island. According to Lord,¹ their considerable variation in composition is chiefly due to differentiation, in place, of a deep seated basic magma. He sees in the amphibole reaction-rims between feldspar and both olivine and diallage some evidence of regional metamorphism. Though these reaction-rims may be susceptible of other interpretations, the main idea of differentiation seems tenable.

A preliminary study of the olivine in a specimen from the east side of the island, near White Head, indicated that it contained an unusually high percentage of iron. It was therefore decided to separate and analyze this olivine as a contribution to the study of the behavior of iron in the crystallization of rock magmas. Though the separation of the olivine in highly satisfactory purity was not attained, yet the results seem worthy of record.

The rock containing the olivine may be designated as an olivine-gabbro, since it is composed of approximately 50% feldspar (near bytownite), 15% olivine, 10% "diallage," and needle-like amphibole in green and in colorless varieties, brown hornblende, magnetite and serpentine, together amounting to 25%.

Preliminary separation using Thoulet's solution of Sp. Gr. 2.9 removed feldspar and serpentine satisfactorily, but attempts to isolate the olivine by use of Klein's solution, even after a strong

¹ Lord, E. C. E.: Notes on the Geology and Petrography of Monhegan Island, Maine, *Am. Geologist*, 26, 328 (1900).

electromagnet had removed those diallage grains that were considerably contaminated with magnetite, did not yield olivine of sufficient purity for quantitative analysis.

A qualitative trial seemed to indicate that solubility in hydrochloric acid might furnish a fairly satisfactory means of ascertaining the chemical composition of the olivine, and the results seem to substantiate this view. Concentrated acid was diluted with twice its volume of water and allowed to act for 24 hours, with occasional warming, on the powdered mineral of grain size .02 to .085 mm.

As a check on the solubility of the minerals contaminating the olivine, two samples of widely different compositions were used, one with 13.5% impurity and the other with 46%, as estimated by grain-count of the powders. In the residue after treatment with HCl, the sharp angular shape of the grains was retained, indicating but little solution in the acid.

The procedure recommended by Washington² was followed after removal of the insoluble residue. Unfortunately both silica determinations were vitiated in the course of the analysis. Qualitative tests for manganese, calcium and titanium were negative.

The following table summarizes the results, and shows the analysis of a similar olivine for comparison.

	1	2	3	4	5	6
SiO ₂			35.96	37.59	38.40	37.17
FeO	22.63	22.42	23.11	22.86	22.98	22.54
MgO	40.05	38.80	40.93	39.35	38.62	39.68
Al ₂ O ₃ , etc.	2.12	1.91				
	64.80	63.13	100.00	100.00	100.00	99.39

1. Olivine, Monhegan, dissolved from sample with 13.5% impurities.
2. Olivine, Monhegan, dissolved from sample with 46% impurities.
3. Analysis 1 recalculated to 100% after deducting Al₂O₃, etc.
4. Analysis 2 recalculated to 100% after deducting Al₂O₃, etc.
5. Calculation from theoretical formula of an olivine with FeO an average between analyses 3 and 4.
6. Olivine from Mount Bruno, Quebec, T. S. Hunt; *Am. Jour. Sci.*, 283 (1860).

It seems clear from the nature of the minerals other than olivine in the powders used for analysis,—chiefly diallage and amphiboles, that calcium should appear, especially in analysis 2, if these

² Washington, H. S.: *Chemical Analysis of Rocks*, 1919.

are soluble to any extent under the conditions of solution employed. This was not the case.

The specific gravity of the olivine was determined to be $3.46 \pm .02$.

The indices of refraction were determined by matching α , β and γ with mixtures of α -monochloronaphthalene and methylene iodide in yellow light from a monochromator. Dr. J. H. C. Martens kindly determined the indices of these mixtures on a refractometer in sodium light, obtaining the values 1.6807, 1.7057 and 1.7185. The value of β is a little lower than would be indicated by interpolation in the series of Penfield and Forbes.³ This may indicate that the rate of increase of β with increasing FeO content is even slower at the magnesium end of the series than is shown by their diagram. The same indication may be seen in their data. As would be expected from its composition the olivine is negative.

Like the mineral from Mt. Bruno, analysis of which has just been quoted, the percentage of FeO is extremely high for a rock-forming olivine.

More extensive details as to methods and results are given in the writer's thesis for a Master's degree which is deposited in the library of Cornell University.

NOTES AND NEWS

"FINGER PRINTS" OF MINERALS

A. N. WINCHELL, *University of Wisconsin.*

Recent developments in our knowledge of X-rays have made it possible to use them in the study of all sorts of solid matter. Truly solid matter consists exclusively of crystals each of which is composed of atoms having a perfectly definite and regular arrangement. These atoms form parallel planes in various positions through the crystal just as the hills of corn planted by machine on a level field form parallel straight lines in several positions across the field. The distance between any two adjacent planes determines the angle at which X-rays are reflected (in phase) by these planes. By exposing a finely powdered crystal to a beam of X-rays reflections can be obtained simultaneously from all the parallel planes in the crystal. These reflections make angles with the incident beam of X-rays which depend directly upon the distances between the planes of atoms. All crystals of the same kind produce reflections which are identical in intensity and positions while two crystals which are not alike produce reflections which are unlike.¹ Accord-

³ Penfield and Forbes: *Am. Jour. Sci.*, 151, 134 (1896).

¹ A few exceptions to this rule have been discovered; most of these are easily understood.

ingly, every kind of crystal can be made to produce its own characteristic X-ray pattern or autograph.

Scientists in this country and in Europe have obtained such autographs or "finger prints" and studied them in various ways. So far as known to the writer, no scientist nor institution has attempted to establish a reference collection of standard autographs and the Department of Geology of the University of Wisconsin has undertaken this task.

Such autographs are most valuable as reference standards when they are obtained from substances whose nature and composition are fully known. Therefore, analyzed samples of all kinds of minerals are needed for the establishment of such standards. A very small portion of the material is sufficient—in some cases an autograph can be made from 50 milligrams of mineral.

In order to make it possible to identify X-ray patterns from unknown material it is important to make the collection of autographs from known material as complete as possible. At the present time about 550 autographs have been made, which include only 170 standards, the others being for purposes of identifying unknown minerals, for special problems relating to crystal structure, etc. The Department of Geology of the University of Wisconsin is anxious to obtain analyzed mineral samples to enlarge its collection of standard autographs as rapidly as possible. For this reason an X-ray pattern of such material will be supplied free of charge to any one supplying a sample together with an accurate chemical analysis.

The Department believes that this collection of "finger prints" of minerals will be very useful to mineralogists, geologists, mining engineers, metallurgists, chemists, and many others. In order to make the service as widely useful as possible X-ray patterns on unanalyzed or unknown material will be made at a minimum charge of \$2.00 each.

The Department has on hand at present standard X-ray patterns of the following minerals, but very few of these are from analyzed samples, and analyzed samples will be acceptable whether included in the following list or not: acanthite, actinolite, albite, almandite, amblygonite, analcite, andesine, andradite, anhydrite, ankerite, anorthite, anthophyllite, antigorite, apophyllite, arsenopyrite, asbestos, augite, azurite, barite, bauxite, beryl, biotite, bismuthinite, bornite, boulangerite, bourbonite, breithauptite, brucite, cassiterite, celestite, cerargyrite, cerussite, chabazite, chalcocite, chalcopyrite, chlorite, chromite, chrysotile, cinnabar, clinocllore, copper, corundum, covellite, cristobalite, diaspore, embolite, enargite, franklinite, freibergite, gahnite, galena, garnet, gibbsite, glauconite, gmelinite, goethite, graphite, greenalite, grossularite, gypsum, halite, halloysite, harmotome, hausmannite, hematite, heulandite, hornblende, iron, ilmenite, kaolinite, labradorite, laumontite, lepidolite, leverrierite, limonite, linneite, lithiophilite, magnetite, manganite, marcasite, molybdenite, montebrazite, muscovite, natrolite, niccolite, oligoclase, orthoclase, petalite, phillipsite, proustite, psilomelane, pyrargyrite, pyrite, pyrolusite, pyromorphite, quartz, realgar, riebeckite, rutile, sal ammoniac, scolecite, siderite, silver, smaltite, smithsonite, sphalerite, spinel, spodumene, stannite, stibnite, stilbite, sulphur, sylvite, tantalite, tennantite, tetrahedrite, thomsonite, titanite, topaz, tourmaline, tremolite, ullmannite, witherite, wurtzite, zinnwaldite.

THE CORRECT MINERALOGICAL NAME FOR
CUPRIC CHLORIDEEDGAR T. WHERRY, *Washington, D. C.*

In view of the magnitude of the sixth edition of Dana's System of Mineralogy, the percentage of errors in it is almost incredibly small, nevertheless a few do occur. One of these concerns the name for cupric chloride, on page 174, which was copied on line 17, page 19, in the January number of this Journal. The Italian term applied by Scacchi to this mineral was erioalco, evidently derived from the Greek *erios*, signifying wool, and *chalcos*, copper. Through overlooking this derivation, and confusion with the other Scacchi name eritrosidero, correctly transliterated erythrosiderite, Dana made the name for the green mineral containing no calcium "erythrocalcite." The correct English transliteration is clearly *eriochalcite*.

BOOK REVIEWS

DIE KÜNSTLICHEN EDELSTEINE. Eine zusammenfassende Darstellung. ihrer Unterscheidung von dem natürlichen und ihrer Stellung im Handel. Mit je einem Abschnitte über Verfälschungen der Edelsteine und über Perlen. Hermann Michel. 2d edition. VIII+477 pages, 2 colored plates, 180 text figures. Verlag von Wilhelm Diebener, *Leipzig*, 1926. Price 25 Mks.

This is the second edition of Doctor Michel's work on the synthetic gem stones the first having appeared in 1914. There are a number of additions, including a discussion of crystal structure and a new chapter on pearls. The part devoted to the examination of the synthetic stones is considerably enlarged and includes methods devised by the author based on color and luminescent effects.

The book begins with a short discussion of the natural occurrence of gem minerals. The second chapter deals with the synthesis of some of the gem minerals, the summary of the literature of corundum and diamonds being particularly complete. The synthetic production of the corundum gem material has reached enormous proportions, one plant alone is capable of producing five million carats monthly.

The examination of the natural and synthetic stones is taken up in detail. An interesting discussion concerns the determination of the place of origin of natural stones by means of inclusions, luminescence, etc. Burma rubies, for instance, show a lively fluorescence under the various rays, Siam rubies only feebly so.

The new chapter on pearls discusses their origin, culture and imitation, also their examination with the pearl microscope as devised by the author.

The book is well printed on heavy paper, the illustrations are good and the book on the whole is very readable and attractive.

W. F. FOSHAG

TRACHTEN DER KRISTALLE. H. Tertsch. 8 vo. VIII+222 pages, with 58 text figures. Forschungen zur Kristallkunde, No. 1, Gebrüder Borntraeger, *Berlin*, 1926. Price 15 Mks.

This splendid monograph presents a comprehensive survey of the various contributions in the field of crystal habit. The list of papers considered contains 181 entries, most of which are discussed in the text. By his concise and critical

treatment of the various phases of crystal habit and related phenomena the author has rendered an excellent service to the many investigators now studying these interesting problems.

EDWARD H. KRAUS

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, April 7, 1927.

A stated meeting of the Philadelphia Mineralogical Society was held on the above date; the vice-president, Mr. Clay, presided. Twenty-three members and four visitors were present.

Mr. Harold Poole of Miquon, Pa., was elected to membership.

Mr. Samuel G. Gordon presented a paper on *A Preliminary Note on Metavauxite, a New Phosphate Mineral from Llallagua, Bolivia*. It has the following properties: colorless or white; luster, vitreous or silky; form, acicular crystals or radiating fibrous aggregates; hardness 3; specific gravity 2.34. Monoclinic: $a:b:c=1.2044:1:0.7272$; $\mu=61^{\circ}19'$; $p_0=0.6037$, $q_0=0.6379$; $e=0.4800$; habit prismatic. Optically +, $X=b$, $Z \wedge c=17^{\circ}$; $\alpha=1.550$, $\beta=1.561$, $\gamma=1.577$; $\gamma-\alpha=0.027$. The formula from an analysis by Mr. Earl V. Shannon is compared below with those of vauxite, paravauxite, etc.

Vauxite (blue) $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 6\text{H}_2\text{O}$	Triclinic
Paravauxite $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$	Triclinic
Metavauxite $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$	Monoclinic
Lazulite $(\text{Fe}, \text{Mg})\text{O} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot \text{H}_2\text{O}$	Monoclinic
Wavellite $2\text{Al}_2\text{O}_3 \cdot 2\text{P}_2\text{O}_5 \cdot 2\text{Al}(\text{OH}, \text{F})_3 \cdot 10\text{H}_2\text{O}$	Orthorhombic

Mr. Biernbaum reported on a trip taken by several members to Avondale and Lieperville, Delaware Co. He exhibited cyanite from Ridley Park and Mr. Clay displayed garnet, likewise collected on this trip. Mr. Hoadley reported on trips to Danbury, Conn., where at the original locality danburite was found; and Monroe township, Conn., where native bismuth was collected. Other localities were visited and the specimens collected exhibited. Dr. Wills described a trip to the Poorhouse Quarry where he found chesterlite.

Dr. Wills then addressed the society on *Microscopic Mineralogy*. The technique of preparing and mounting specimens was described, the speaker exhibiting many box mounts. Six revolving tables, each equipped with a microscope were used, and the members seated about these tables examined the choice mounts which were shown.

F. A. CAJORI, *Secretary*

NEW YORK MINERALOGICAL CLUB

Regular Monthly Meeting of March 16, 1927.

At the regular meeting held on March 16 Miss Catherine Schroder read an interesting paper on the *Minerals of British Columbia*. The speaker touched upon the minerals associated with those of economic value around Banff and Lake Louise, Alberta. She also spoke of the gold and silver locality over the boundary line in

British Columbia. She described the placer mining for gold in the Caribou District of British Columbia, and mentioned the valuable lode district of southeastern British Columbia as furnishing many specimens of minerals. Lake Kootenai in this district furnishes mainly gold, lead, copper and zinc minerals. Among the minerals described and illustrated by specimens were gold, pyrrargyrite, fluorite, cassiterite, galena, cerussite, siderite and molybdenite.

The second paper was given by Dr. Alfred C. Hawkins, who spoke on the *Minerals of Western New York*. Dr. Hawkins mentioned the localities of Rochester, Lockport and Syracuse as rich in minerals. Emphasizing the Rochester locality he cited pyrite of a dodecahedral habit in dolomite as one of the rare occurrences. He described the dolomite of Rochester as being white rather than yellow and mentioned light purple fluorite as occurring in the cavities of the dolomite. Of less frequent occurrence in these cavities are selenite, anhydrite, celestite, galena and sulphur. At Lockport the dolomite contains selenite, fluorite and calcite. Between Rochester and Lockport are several quarries which have not been visited. In conclusion, Dr. Hawkins showed a number of excellent slides of the region.

Dr. George F. Kunz showed a magnificent topaz crystal from Burma which was cinnamon brown in color, and was the largest found in the locality. Also a suite of blue zircons both cut and uncut. He stated that the blue color was in reality produced from hyacinth zircons by the action of cobalt nitrate and potassium ferrocyanide vapors. He suggested that for these artificially colored stones the name of "Starlight" be used.

Mr. O. I. Lee showed several rare minerals including naëgite (an altered zircon), turanite, schizolite, taeniolite and erikite.

HERBERT P. WHITLOCK, *Secretary*

NEW MINERAL NAMES

Aramayoite

L. J. SPENCER: Aramayoite, a new mineral, from Bolivia. With the chemical analysis by E. D. Mountain. *Mineral. Mag.*, 21, No. 115, pp. 156-162 (1926).

KATHLEEN YARDLEY: X-ray examination of aramayoite. *Ibid.*, pp. 163-168.

NAME: In honor of Señor Don Felix Avelino *Aramayo*, former Managing Director of the Compagnie Aramayo de Mines en Bolivie.

CHEMICAL PROPERTIES: A sulfide of silver, bismuth and antimony. Formula: $\text{Ag}_2\text{S} \cdot (\text{Sb}, \text{Bi})_2\text{S}_3$. Analysis: S 20.87, Sb 29.95, Bi 13.75, Ag 34.74, Cu 0.53, Fe tr.; Sum 99.84.

CRYSTALLOGRAPHIC PROPERTIES: Triclinic. $a:b:c=0.9972:1:0.9886$. $\alpha=86^\circ 55'$, $\beta=90^\circ 53'$, $\gamma=93^\circ 18'$. Cleavage $c(001)$ perfect. Angle between the perfect and the fibrous cleavage is about 77° .

PHYSICAL AND OPTICAL PROPERTIES: Color, iron black. Lustre, brilliant on the perfect cleavage. Thin cleavage flakes are pliable but not elastic. Somewhat sectile. Streak black. $H=2.5$. Very thin edges show a deep blood red color. Sp. Gr. 5.602.

OCCURRENCE: Found in the Animas Mine of the Compagnie Aramayo de Mines en Bolivie at Chocaya, province Sud-Chichas, Dept. of Potosi, Bolivia. Associated with massive tetrahedrite and pyrite.

Upon a specimen of this mineral in the collection of the United States National Museum (No. 95,553, gift of Jack Hyland) that had been partially investigated at the time the above papers appeared, Dr. M. N. Short of the U. S. Geological Survey has determined the following metallographic properties: Color white, anisotropic. HNO_3 stains iridescent, action slow in starting, KOH stains iridescent. HCl , KCN , FeCl_3 and HgCl_2 negative.

W. F. FOSHAG

Norbergite

PER GEIGER: Norbergite and fluoborite, two new minerals from the Norberg Mining District. *Geol. För. Förh.*, Stockholm, 48, 84, 1926 (Preliminary description). *Sver. Geol. Undersökning*. Yearbook 20, No. 4, p. 16 (1927).

NAME: From the district in which it was found: *Norberg*, Sweden.

CHEMICAL PROPERTIES: A hydrous magnesium silicate of the chondrodite group. Formula: $\text{Mg}_2\text{SiO}_4 \cdot \text{Mg}(\text{F},\text{OH})_2$. Analysis: SiO_2 28.54, Al_2O_3 0.09, Fe_2O_3 0.69, FeO 0.82, MgO 56.45, CaO 1.01, MnO 0.18, F 13.70, H_2O 2.90, CO_2 1.21. Sum ($-\text{O}=\text{F}$ 15.77)=99.82.

PHYSICAL AND OPTICAL PROPERTIES: Color pink with purplish tinge to whitish. Biaxial, positive. $2E=82^\circ$. $2V=49^\circ 30'$. $\alpha=1.563$, $\beta=1.567$, $\gamma=1.590$. $H=6.5$. Sp. Gr. 3.13–3.15.

OCCURRENCE: Found at the Ostanmosoa iron mine, Norberg, associated with tremolite and a peculiar variety of allanite replacing a dolomitic limestone. Chondrodite is abundant in other parts of the same mine.

W.F.F.

Fluoborite

PER GEIGER: *Ibid.*, page 85.

NAME: From its composition. A magnesium fluoborate.

CHEMICAL COMPOSITION: A hydrous fluoride and borate of magnesium. $3\text{MgO} \cdot 3\text{B}_2\text{O}_3 + 3\text{Mg}(\text{F},\text{OH})_2$. Analysis: SiO_2 0.45, Al_2O_3 0.91, Fe_2O_3 0.81, MgO 61.65, MnO 0.05, F 9.30, B_2O_3 17.90, H_2O 10.78, CO_2 1.36. Sum ($-\text{O}=\text{F}$ 3.92)=99.28.

CRYSTALLOGRAPHIC PROPERTIES: Hexagonal. $c=3.09 \text{ \AA}$, $a=9.05 \text{ \AA}$. $a:c=0.341$ (from x-ray data).

PHYSICAL AND OPTICAL PROPERTIES: Colorless. Uniaxial negative. $\omega=1.566$, $\epsilon=1.528$. $H=\text{below } 5$, probably $3\frac{1}{2}$. Sp. Gr. 2.89.

OCCURRENCE: From the Tallgruvan mine, east of Kallmora, Norberg, associated with magnetite, ludwigite, chondrodite, szaibelyite (?) and their alteration products replacing a dolomite.

DISCUSSION: Fluoborite is probably identical with an unknown mineral associated with ludwigite and szaibelyite from Lincoln County, Nevada, described by J. L. Gilson and Earl V. Shannon (*Am. Mineral.*, 10, 137, 1925).

W.F.F.